REGULATORY DECISION-MAKING UNDER UNCERTAINTY:

THE CASE OF ALAR*

* This is a teaching case commissioned by the Harvard Center for Risk Analysis for use by the Office of Continuing Education, Harvard School of Public Health, for a course on Risk Analysis in Environmental & Occupational Health, September 5-7, 1990. The case was written by Ms. Susan Moses under the supervision of Dr. John D. Graham.

As Jack Moore, Acting Administrator of the U.S. Environmental Protection Agency (EPA), hung up the phone, he wondered whether he should agree to an interview with Ed Bradley for a 60 Minutes segment on pesticides.

It was January 1989, George Bush had just been inaugurated as President, and the Administration had not put forth its policies on environmental issues. Jack Moore was Acting Administrator of EPA. He had most recently held the position of Assistant Administrator for Pesticides and Toxic Substances at EPA. As an advocate for the use of sound science in the regulatory decision-making process, he had good working relationships with both industry and environmentalists alike. Twice before Dr. Moore had been asked to appear on 60 Minutes (prior to being in the position of Acting Administrator), and both times he declined. He was under no pressure from The White House; it was his decision whether to grant the interview or not. Not too long ago, Dr. Moore had received an informal copy of a not-yet-released report on pesticides in children's food, written by the Natural Resources Defense Council (NRDC), an advocacy group. He now began to wonder whether or not there might be some connection between this report and the scheduled 60 Minutes segment, particularly since Ed Bradley had referred to the pesticide Alar, a registered trademark for the chemical daminozide that is sprayed on apples. Alar, and its metabolite unsymmetrical dimethylhydrazine (UDMH), were highlighted in the NRDC report as potential hazards.

Knowing that 60 Minutes is watched by millions of viewers, Jack Moore began to evaluate the implications of his appearance on the show and wondered how he should prepare himself if he agreed to the interview with Ed Bradley.

THE FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), enacted in 1947, is the federal law regulating pesticide products and their use in the United States. Until 1972, the law focused on the proper labeling of pesticide products. In 1972, amendments were passed changing FIFRA from a labeling law to a more comprehensive statute that charged EPA with the responsibility of premarket data review and registration. These changes reflected public concern about potential adverse health effects and the need to evaluate the "reasonableness" of any of these risks. Since 1972 there have been a series of FIFRA amendments, and the debate over the adequacy of the current law in protecting human health and the environment continues today.

FIFRA is a "risk-balancing" statute. EPA weighs any potential adverse effects of the product against its benefits as part of the decision-making process. The operating words of the statute are that the pesticide, when used as directed, "will not cause any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide." This risk/benefit mandate is in contrast

to other laws, such as the Delaney Clause of the Federal Food, Drug, and Cosmetic Act, which bans the use of any intentional food additive that is shown to be a carcinogen in humans or animals, regardless of any benefits.

All pesticide products must be registered by EPA prior to being marketed and distributed in commerce. Manufacturers must submit toxicological and environmental data to the Agency as part of their application for product registration. EPA reviews these data for short-term and long-term toxicity, mutagenicity, oncogenicity, fetotoxicity, teratogenicity, for effects on wildlife and other organisms, and for environmental fate and residues in food or feed.

Under the Federal Food, Drug, and Cosmetic Act, EPA sets tolerances for pesticide residues in food. A tolerance is the maximum level of residue permitted in the raw harvested commodity and on processed forms of the commodity.

If EPA approves a pesticide registration application, the product may be manufactured for commerce. However, each product is approved to control specific pests, for use on specific crops, and for use in specific concentrations and frequency of application.

All pesticides that were on the market prior to the enactment of FIFRA were "grandfathered" under the statute. Therefore, it is possible that many of these products would not be approved today under the current pesticide registration procedure. However, EPA is in the process of reviewing these "existing" pesticides to

determine whether any of them should be withdrawn from the market because of potential harmful effects. The Agency is under Congressional pressure to move more quickly in its evaluation of these grandfathered substances.

The burden of proof as to the "safety" of a new pesticide rests with the manufacturer submitting the registration application. If for whatever reason the Agency determines that the terms of the registration are not being met, EPA may begin the "Special Review" process for canceling the registration. At this point, the burden of finding "unreasonable risk" is shifted to the Agency.

This review is a process, formerly called the Rebuttable Presumption Against Registration (RPAR), whereby EPA collects and evaluates information on the pesticide and can request additional information from the manufacturer to determine whether any uses of the pesticide "cause unreasonable adverse effects to human health or the environment."

Depending on the nature of the new data, the Agency may propose changes to the terms of the registration under the rationale that such changes reduce risks to the level where the benefits outweigh the risks; or, EPA may proceed with cancellation by issuing a "Notice of Intent to Cancel" if the Agency finds that the risks outweigh the benefits. Throughout this entire process, the public has the opportunity to submit comments in an effort to affect any regulatory action.

THE SCIENTIFIC ADVISORY PANEL (SAP)

The Scientific Advisory Panel (SAP), a standing advisory committee, was mandated in 1975 by FIFRA to review, for potential regulatory action, EPA's evaluations of environmental and health risks posed by specific pesticides.

Regulatory History of Alar

Alar, the Uniroyal Chemical Company trade name for daminozide, was first registered with the Environmental Protection Agency (EPA) as a plant growth regulator for potted chrysanthemums in 1963. The first registered food use was for apples in 1968. To apple growers, Alar was a major breakthrough; ripe apples stayed on the tree longer, and remained firmer and redder (better market quality) during harvest and storage. The tolerance (maximum permissible residue level) for Alar in apples was set at 30 ppm. From 1968-1985 Alar was also registered for use on cherries, nectarines, peaches, pears, grapes, peanuts, tomatoes, and ornamental plants. However, in 1985 it was estimated that approximately 75% of the daminozide in commerce was used on apples; since that time usage has declined significantly (EPA, 1989).

In the summer of 1984, EPA issued a Notice of Initiation of a Special Review of pesticide products containing daminozide, which indicated that the Agency was going to investigate potential harmful effects of the pesticide. Of particular concern was a

degradation product of daminozide, unsymmetrical dimethylhydrazine (UDMH). Data from animal studies indicated that both daminozide and UDMH elicited "statistically and biologically significant oncogenic responses at multiple organ sites in multiple species and strains of animals. UDMH was believed to be a very potent animal carcinogen and mutagen." (EPA, 1989) Although the database was limited, the Agency decided to proceed with a cancellation action.

A year later, in the fall of 1985, EPA developed a combined Preliminary and Final Determination and Draft Cancellation Notice. The process was accelerated in light of the potentially high dietary exposure of daminozide and UDMH to children.

The EPA Scientific Advisory Panel (SAP), required under FIFRA to review this documentation, believed that while the data raised concerns, they were not sufficient to support a quantitative risk assessment for either daminozide or UDMH. The Department of Agriculture (USDA) also reviewed the report and argued that EPA had underestimated the benefits of daminozide use, and therefore, should reassess its call for cancellation. Although not legally bound by the SAP decision, the Agency decided to reassess its position based on the SAP recommendation, and chose not to proceed with the cancellation action. The Agency did require Uniroyal to conduct additional testing and collect additional data on the oncogenic risk of daminozide and UDMH. In the interim, to reduce exposure, EPA lowered the tolerance for daminozide residues on apples from 30 ppm to 20 ppm. However, this tolerance was set to

expire on July 31, 1987 at which time EPA believed it would have additional data to evaluate the tolerance further. The Agency also instructed Uniroyal to include a use advisory with its product warning not to use the chemical on apples intended for use in apple sauce and apple juice. (When apples are processed into apple sauce and juice, the heating process causes daminozide to break down into UDMH. Therefore, these products have higher concentrations of UDMH.)

At the time, Jack Moore felt that there was enough evidence for EPA to be concerned about the carcinogenic potential of daminozide and its metabolite UDMH, but not enough from a legal point of view to regulate Alar under FIFRA. Unlike the requirements for new pesticides where the registrant must bear the burden of proof that "the intended use will not present an unreasonable risk," for currently registered chemicals such as daminozide, the burden of finding "unreasonable risk" lay with EPA.

In 1985-86, when the carcinogenic potential of Alar was made public, consumers acted predictably--they stopped buying apples until they were assured by their grocers and food processors that the apples in their stores and products were Alar-free. The protest was relatively calm, and short-lived.

Over the next several years (1986-88), NRDC, Public Citizen, and the States of New York and Maine petitioned and then sued EPA for not amending the tolerance for daminozide residue to zero. The Agency claimed it did not have sufficient data to determine

whether these residues (20 ppm) posed a health hazard to the U.S. population. The case was dismissed.

In 1987, the available residue and toxicological data were not sufficient to determine if a new tolerance would be adequate to protect public health. Therefore, the 20 ppm tolerance was extended to January 31, 1989 when new data would be available.

Beginning in 1988, tests by independent laboratories revealed that claims by one grocery chain of selling Alar-free apples and products were false. Once again, fear of eating Alar-treated products caused some consumers to stop buying apples and apple products.

In early January 1989, EPA staff recommended to Jack Moore to seek cancellation of all food uses of daminozide. This decision was based on the new data collected that indicated "that dietary exposure to UDMH represents a significant carcinogenic risk which outweighs the benefits of use of daminozide on food crops and therefore warrants the cancellation of the food uses of daminozide" (EPA, 1989, p.ii). Agency staff estimated the lifetime risk of cancer for the general population from dietary exposure to UDMH to be 4 in 100,000. Infants up to one year are considered the highest exposure group.

EPA also estimated the benefits derived from the use of daminozide. The calculations were based on the economic impacts that would result if daminozide were banned. The greatest impact would be on the apple industry, as there are "no alternatives to daminozide that alone will accomplish all of the growth regulator

benefits attributed to daminozide" (many of which relate to the appearance of the fruit). The overall effect on all growers is estimated to be "an annual income increase of $1.5 million" resulting from higher market apple prices, with daminozide users losing $14.5 million and non-users gaining $16.1 million. Growers of certain apple varieties (particularly Eastern McIntosh and Stayman), however, may experience annual income losses of $5.7 and $1.8 million, respectively.

In addition, a cancellation of Alar was estimated to reduce the supply of fresh apples. "The net social cost (total society cost) of cancellation of daminozide use on apples based on 10 percent of the crop treated is estimated to range from $18 to $81 million as compared to $44 to $198 million for 1985 usage levels. Economic impacts of a cancellation for other uses of daminozide, such as on cherries, grapes, peanuts, and ornamentals, are predicted to be much less significant. In addition to the apple industry, peach growers' losses were estimated to range from $1.5 to $5.5 million (EPA, 1989).

The Agency staff did not recommend issuing an emergency suspension of daminozide use on food crops because while the data did indicate cause for concern, "the level of risk during the time necessary to complete a cancellation action is not unreasonably high." (EPA, 1989). According to FIFRA, an immediate suspension is warranted only if EPA determines that the risks present an immediate hazard. In the interim it was also expected that usage would decline, thereby lowering the risk of exposure.

RISK ASSESSMENT DATA

In historical studies from 1977-78, as well as more recent data submitted by Uniroyal, daminozide produced vascular and lung tumors in mice. However, this oncogenic response may be linked to the presence of UDMH in the test material (possibly by metabolic conversion). UDMH also produced vascular and lung tumors. On the other hand, the data from rat studies for both daminozide and UDMH is less significant. More specific information on these studies is shown in Table 1.

The estimates of daminozide and UDMH residues in raw and produced foods are shown in Tables 2 and 3. The estimates of dietary exposure for the U.S. population as well as for specific age subsets are shown in Tables 4-9.

The lifetime risk of cancer for the general population due to dietary exposure to UDMH was estimated to be 4 - 5 x 10-5. However, because children have a high ratio of food intake for their bodyweight and because such a high proportion of their diet comes from foods that may have high levels of daminozide and/or UDMH residues, a cancer risk of 5-6 x 10-6 was estimated.

THE NRDC REPORT

The NRDC study, "Intolerable Risk: Pesticides in our Children's Food" examined the levels of pesticide residues found

in fruits and vegetables to determine whether they presented a health hazard to preschoolers. The NRDC report quantified the preschooler's dietary exposure to 23 pesticide residues in 27 food items as well as the resultant potential health risks in terms of two endpoints--cancer and disruption in central nervous system functioning.

The principal findings of the study were that

> "Preschoolers are being exposed to hazardous levels of pesticides in fruits and vegetables. Between 5,500 and 6,000 (a risk range of 2.5 x 10 to 2.8 x 10) of the current population of American preschoolers may eventually get cancer solely as a result of their exposure before six years of age to eight pesticides or metabolites commonly found in fruits and vegetables." (NRDC report, p.2)

The report singled out UDMH as "the greatest source of the cancer risk identified by NRDC." This risk was estimated as "240 times greater than the cancer risk considered acceptable by EPA following a full lifetime of exposure;" one out of 4000 children will get cancer as a result of ingesting Alar-treated apples.

The report also recommended that Congress amend the current pesticide regulations to "close loopholes in EPA's and FDA's regulatory programs." Furthermore, NRDC raised concerns about how long it takes to lower tolerances or remove hazardous pesticides from the market, and recommended that EPA be granted the authority to take action more quickly. (The Executive Summary of the NRDC report is attached.)

REGULATORY ACTION

With his staff's data analyses and recommendations in hand, the current tolerance on Alar in apples due to expire January 31, 1989, and the findings of the NRDC report soon to be released, Jack Moore had to make a decision on Alar in addition to deciding whether or not to be interviewed for 60 Minutes.

STUDY QUESTIONS

1. Should Jack Moore appear on 60 Minutes? Discuss the pros and cons of this decision, taking into account the fact that he is Acting Administrator of EPA.

2. If he agrees to the interview, how should Jack Moore prepare himself?

3. What regulatory decision should the Agency make on Alar? Should Jack Moore reveal this decision during his 60 Minutes interview?

4. In addition to "Why hasn't EPA banned Alar?" and "Is the current law adequate to protect the public from the risks of pesticides?", what additional questions should Jack Moore anticipate, and how should he respond?

5. What factors in addition to the "scientific facts" must Jack Moore consider in his decision-making concerning Alar?

6. Is the current law adequate to protect the public from the risks of pesticides?

TABLE 1

NEOPLASTIC RESPONSE REPORTED FOR DAMINOZIDE AND UDMH IN RODENT CARCINOGENICITY STUDIES

Study Name	Species & Route	Tumor Site and Potency (if Calculated)
DAMINOZIDE		
Toth, 1977	Swiss mouse (drinking water)	Blood vessel sarcomas in males and females; alveolar/bronchiolar adenomas and carcinomas in males and females; kidney tumors in males
NCI, 1978a	$B6C3F_1$ mouse (dietary)	Liver carcinomas in males; alveolar/bronchiolar carcinomas and adenomas in males and females
NCI, 1978b	F344 rat (dietary)	Uterine endometrial adenocarcinomas and leiomyosarcomas in females
Uniroyal, 1988a	CD-1 mouse (dietary)	Dose-related trend with regard to blood vessel tumors of liver in males and females; dose-related increase in alveolar/bronchiolar adenomas in males and females; no increases in vascular or lung tumors by pairwise comparison
UDMH		
Toth, 1973	Swiss mouse (drinking water)	Hemangiomas and hemangiosarcomas of liver in males and females; alveolar/bronchiolar adenomas and carcinomas in males and females; kidney and liver tumors in males and females; Q^*_1 estimated to be 8.9 $(mg/kg/day)^{-1}$
Toth, 1977	Hamster (drinking water)	Hemangiomas and hemangiosarsarcomas in males; colon tumors in males and females
Haun, 1984	F344 rat (inhalation)	Pancreatic islet cell adenomas and carcinomas in males; Q^*_1 estimated to be 2.45 $(mg/kg/day)^{-1}$; pulmonary adenomas and carcinomas in males
Haun, 1984	C57BL/6 mouse (inhalation)	Hemangiomas and hemangiosarcomas in females; liver adenomas in females
Uniroyal, 1988e	CD-1 mouse (drinking water)	Blood vessel tumors of the liver in males and females; Q^*_1 estimated to be 0.88 $(mg/kg/day)^{-1}$; alveolar/bronchiolar adenomas in males and females; Q^*_1 estimated to be 2.9 $(mg/kg/day)^{-1}$

TABLE 2

ESTIMATES OF DAMINOZIDE LEVELS IN RAW AND PRODUCED FOODS

COMMODITY	PERCENT OF CROP TREATED	AVERAGE, ppm DAMINOZIDE *
Apples		1.00
Apple sauce (-baby)		0.50
" " (-adult)		0.40
Apple juice (-baby)		0.50
" " (-adult)		0.40
Dried raw apples		8.00 #
Dried cooked apples		4.00 #
Cherries, sweet and sour	30	23.7
Cherry filling (and juice)		1.5
Grapes		0.0
Grape juice		0.02
Grape preserves		0.02
Nectarines	3	14.5
Peaches	3	11.3
Peaches, canned		11.3
Peanuts		0.80
Peanut butter		0.80
Peanut oil		0.80
Pears	3	8.8
Pears, canned		8.8
Beef meat		0.01
" kidney		0.2
" fat		0.01
" milk		0.01
Poultry meat		0.001
" eggs		0.002
Tomatoes, whole	10	0.20
Tomato juice	10	0.30 #
Tomato puree	10	0.66 #
Tomato paste	10	1.10 #
Catsup	10	0.50 #

* For commodity items beef, beef byproducts, milk, poultry and eggs, the residue values were extrapolated from feeding studies.

\# Residue levels for dried apples includes a concentration factor of 8. For processed tomato products, the average residue of 0.2 ppm was multiplied by the following concentration factors to derive the value used in calculating exposure: 1.5 for tomato juice, 3.3 for tomato puree, 5.4 for tomato paste, and 2.5 for catsup.

TABLE 3

ESTIMATES OF UDMH LEVELS IN RAW AND PRODUCED FOODS

COMMODITY	PERCENT OF CROP TREATED	AVERAGE, ppb UDMH *
Apples		2.6
Apple sauce (-baby)		33.3
" " (-adult)		14.0
Apple juice (-baby)		44.0
" " (-adult)		23.9
Dried raw apples		20.8 #
Dried cooked apples		352.0 #
Cherries, sweet and sour	30	18.6
Cherry filling (and juice)		108.1
Grapes		0.0
Grape juice		1.5
Grape preserves		1.5
Nectarines	3	25.0
Peaches	3	21.3
Peaches, canned		21.3
Peanuts		24.9
Peanut butter		24.9
Peanut oil		24.9
Pears	3	11.9
Pears, canned		11.9
Beef meat		2.0
" kidney		2.0
" fat		2.0
" milk		2.0
Poultry meat		0.5
" eggs		0.5
Tomatoes, whole	10	1.6
Tomato juice	10	2.4 #
Tomato puree	10	5.3 #
Tomato paste	10	8.6 #
Catsup	10	4.0 #

* For beef, beef byproducts, milk, poultry and eggs, the residue values were extrapolated from feeding studies.

\# Residue levels for dried apples includes a concentration factor of 8. For processed tomato products, the average residue of 1.6 ppb was multiplied by the following concentration factors to derive the value used in estimating exposure: 1.5 for tomato juice, 3.3 for tomato puree, 5.4 for tomato paste, and 2.5 for catsup.

TABLE 4

ESTIMATES OF DAMINOZIDE DIETARY EXPOSURE FOR THE U.S. POPULATION *

COMMODITY	AVERAGE DAILY CONSUMPTION (g food/kg bwt/day)	RESIDUE LEVELS (in ppm or mg/kg)	EXPOSURE (mg dam./kg/day)	
Apples, fresh	0.3074	1.00	0.000307	
Apples, cooked: fresh and juice	0.2004	0.50	0.001000	
Dried raw apples	0.0001	8.00	0.000001	#
Dried cooked apples	0.0001	4.00	0.0000004	#
Apple juice, raw	0.1709	0.50	0.000085	
Cherries, raw fresh and raw juice	0.0105	7.11	0.000075	
Cherries, cooked: fresh and juice	0.0251	1.50	0.000038	
Eggs	0.5803	0.002	0.000001	
Grapes	0.0438	0.02	0.000001	
Grape juice	0.0901	0.02	0.000002	
Wine and sherry	0.0842	0.02	0.000002	
Nectarines	0.0130	0.45	0.000006	
Peaches	0.2154	0.34	0.000073	
Peanuts, raw, cooked, and oil	0.0748	0.80	0.000060	
Pears	0.1225	0.26	0.000032	
Meat	2.2318	0.20	0.000446	
Milk	1.3705	0.01	0.000014	
Tomatoes, whole	0.4920	0.20	0.000098	
Tomato juice	0.0551	0.30	0.000017	#
Tomato puree	0.1702	0.66	0.000112	#
Tomato paste	0.0395	1.10	0.000043	#
Catsup	0.0420	0.50	0.000021	#
TOTAL			0.000951 or 9.5×10^{-4} mg/kg/day +	

* For commodity items meat, milk, and eggs, the residue values were extrapolated from feeding studies data.

\# Residue levels for dried apples includes a concentration factor of 8. For processed tomato products, average residue of 0.2 ppm was multiplied by the following concentration factors: 1.5 for tomato juice, 3.3 for tomato puree, 5.4 for tomato paste, and 2.5 for catsup.

\+ 1 percent of exposure (0.95×10^{-5} mg/kg/day) used to estimate UDMH contribution from metabolic conversion of daminozide to UDMH when estimating risk in Table 16.

TABLE 5

ESTIMATES OF UDMH DIETARY EXPOSURE FOR THE U.S. POPULATION *

COMMODITY	AVERAGE DAILY CONSUMPTION (g food/kg bwt/day)	RESIDUE LEVELS (in ppb or ug/kg)	EXPOSURE (ug UDMH/kg/day)	
Apples, fresh	0.3074	2.6	0.000799	
Apples, cooked:				
fresh and juice	0.2004	44.0	0.008818	
Dried raw apples	0.0001	20.8	0.000002	#
Dried cooked apples	0.0001	352.0	0.000035	#
Apple juice, raw	0.1709	33.3	0.005691	
Cherries, raw fresh and raw juice	0.0105	5.6	0.000059	
Cherries, cooked:				
fresh and juice	0.0251	108.1	0.002713	
Eggs	0.5803	0.5	0.000290	
Grapes	0.0438	0.0	0.000000	
Grape juice	0.0901	1.5	0.000135	
Wine and sherry	0.0842	1.5	0.000126	
Nectarines	0.0130	0.8	0.000010	
Peaches	0.2154	0.6	0.000129	
Peanuts, raw, cooked and oil	0.0748	24.9	0.001863	
Pears	0.1225	0.4	0.000049	
Meat	2.2318	2.0	0.004464	
Milk	1.3705	2.0	0.021068	
Tomatoes, whole	0.4920	1.6	0.000787	
Tomato juice	0.0551	2.4	0.000132	#
Tomato puree	0.1702	5.3	0.000902	#
Tomato paste	0.0395	8.6	0.000340	#
Catsup	0.0420	4.0	0.000168	#
TOTAL			0.000047 or 4.7×10^{-5} + mg/kg/day	

For commodity items meat, milk, and eggs, the residue values were extrapolated from feeding studies data. All beef, beef byproducts and poultry were combined under "meat" in this table.
Residue levels for dried apples includes a concentration factor of 8.
For processed tomato products, average residue of 1.6 was multiplied by the following concentration factors: 1.5 for tomato juice, 3.3 for tomato puree, 5.4 for tomato paste, and 2.5 for catsup.
1 percent of daminozide exposure (0.95×10^{-4} mg/kg/day) added to total UDMH dietary exposure in Table 16 used to estimate 1 percent conversion of daminozide in the gut.

TABLE 6

TAS ESTIMATES OF AVERAGE DAILY EXPOSURE TO DAMINOZIDE FOR SELECTED AGE SUBSETS

Subset (Age and Other)	Exposure (mg/kg/day)
AVERAGE (U.S. POPULATION)	0.000951
Nursing infants (<1 year old)	0.003396
Non-nursing infants (<1 year old)	0.005427
Children (1 - 6 years old)	0.002786
Children (7 - 12 years old)	0.001514
Males (13 - 19 years old)	0.000730
Females (13 - 19 years, not pregnant or nursing)	0.000662
Females (13 + years, pregnant)	0.000692
Females (13 + years, nursing)	0.000824
Females (20 + years, not pregnant or nursing)	0.000575
Males (20 + years old)	0.000523

TABLE 7

ESTIMATES OF UDMH DIETARY RISK FOR THE U.S. POPULATION

(interim Q^*_1 = 0.88 mg/kg/day)

Commodity	Dietary Exposure (ug/kg/day)	Dietary Risk *
Milk	0.021068	1.8×10^{-5}
Apples	0.015331	1.4×10^{-5}
Red meat	0.004464	3.9×10^{-6}
Cherries	0.002772	2.4×10^{-6}
Peanuts	0.001863	1.6×10^{-6}
Eggs	0.000290	2.5×10^{-7}
Grapes	0.000261	2.3×10^{-7}
Poultry	0.000252	2.2×10^{-7}
Tomatoes	0.000234-0.00234	2.1×10^{-7} - 2.1×10^{-6}
Peaches	0.000129	1.1×10^{-7}
Pears	0.000049	4.3×10^{-8}
Nectarines	0.000010	8.8×10^{-9}
TOTALS	**0.046715**	**4.1×10^{-5}**
	+[0.009500 estimated metabolic UDMH from daminozide]	0.84×10^{-5}
		4.9×10^{-5}

* Refer to II.C.3.b. "Uncertainties that Could Overestimate the Risk (2-3)".

TABLE 8

The following Table presents the average daily total dietary exposure to daminozide and UDMH, respectively, for various age groups to demonstrate the differences in dietary exposure.

TAS ESTIMATES OF AVERAGE DAILY EXPOSURE TO UDMH FOR SELECTED AGE SUBSETS

Subset (Age and Other)	Exposure (mg/kg/day)
AVERAGE (U.S. POPULATION)	0.000047
Nursing infants (<1 year old)	0.000229
Non-nursing infants (<1 year old)	0.000410
Children (1 - 6 years old)	0.000138
Children (7 - 12 years old)	0.000071
Males (13 - 19 years old)	0.000042
Females (13 - 19 years, not pregnant or nursing)	0.000034
Females (13 + years, pregnant)	0.000027
Females (13 + years, nursing)	0.000037
Females (20 + years, not pregnant or nursing)	0.000023
Males (20 + years old)	0.000025

TABLE 9

Table 9 describes the average incremental risk for individuals who belong to any of the three subgroups for which dietary exposure was estimated. Annual risk was calculated by multiplying the average residue contribution for each subgroup by the interim cancer potency factor ($Q^*1 = 0.88$ (mg/kg/day)$^{-1}$) and then dividing the calculated risk by 70 lifetime years.

ESTIMATES OF RISKS
TO SELECTED AGE SUBSETS AND THE GENERAL POPULATION
FROM ONE YEAR EXPOSURE TO UDMH

Subset (Age and Other)	Dietary Exposure (mg/kg/day)	Annual Risk
Nursing infants (<1 year old)	0.000229	2.9×10^{-6}
Non-nursing infants (<1 year old)	0.000410	5.2×10^{-6}
Children (1 - 6 years old)	0.000138	1.7×10^{-6}
AVERAGE LIFETIME RISK TO THE GENERAL POPULATION FROM ONE YEAR EXPOSURE	**0.000047**	**5.9×10^{-7}**

2. Nondietary risks

The exposure estimates discussed in section II.B.2. are used as a basis for estimating non-dietary carcinogenic risk. The Agency assumed that the cancer potency factor for the dermal route of exposure is equivalent to that for the dietary route (0.88) and that the length of lifetime exposure is 35 years worked/70 years lived. To calculate non-dietary carcinogenic risk from exposure to UDMH, the Agency used the following equation:

UDMH risk = UDMH exposure x 35/70 x Q^*_1(0.88 (mg/kg/day)$^{-1}$)

Based on this calculation, the carcinogenic risks from worker exposure to UDMH is tabulated in Table 18.